AIR QUALITY, PRECIPITATION AND CORROSION STUDIES OF MBO LOCAL GOVERNMENT AREA, NIGERIA

O. B. EKOP
I. R. UDOTONG

ABSTRACT: *There have been persistent reports of air pollution, acid rain and corrosion of roofing sheets by residents of Mbo Local Government Area for the past years. Residents attribute these to the incessant gas flaring by Mobil Producing Nigeria Unlimited (MPNU) operating in the neighbouring Ibeno LGA located in the south of Mbo LGA. The MPNU study of 2002 on the effects of its gas flares on the environment did not cover Mbo LGA. This omission prompted this study. The objectives were to identify and determine ambient concentrations of possible air contaminants that may be emitted through gas flaring, compare these concentrations with acceptable regulatory standards and make recommendations on how to ameliorate the effects. Three sampling stations at Ibaka, Enwang and Etisong Ebughu were chosen for the study. Sampling, data collection, laboratory analyses and results documentation were done in accordance with the recommended procedures and practices for environmental data collection in Nigeria by the Department of Petroleum Resources. The results showed that the concentrations of carbon monoxide, methane and volatile organic compound were above regulatory standards. The acidic pH value of rainwater in the area indicated acid rain caused by oil and gas activities in general and gas flaring in particular. The residents of Mbo LGA deserve compensation from MPNU for the damage done on them and their environment while gas flaring should be stopped henceforth.*

INTRODUCTION

There have been widespread reports and complaints of air pollution, acid rain and corrosion of roofing sheets in Mbo Local Government Area (LGA) in the past years. Residents attribute these to the incessant gas flaring at Qua Iboe Terminal (QIT) and other production platforms (PPs) belonging to Mobil Producing Nigeria Unlimited (MPNU) spread along the Atlantic Ocean Shoreline. These gas flares from MPNU locations they further claim contribute to low agricultural productivity, socio-economic activities and ultimately human health, amongst other effects. These and other effects of gas flaring contribute significantly to global environmental degradation in general and Mbo Local Government Area in particular.

O. B. Ekop *and* ***I. R. Udotong*** *are affiliated with the University of Uyo, Uyo, Nigeria.*

International Journal of Environmental Issues Vol. 2 No.1 & 2

Mobil Producing Nigeria Unlimited (MPNU), the second largest oil producing company in Nigeria and the largest condensate producer in Africa is located within Ibeno. The operational base of the company is located at Qua Iboe Terminal and it has several production platforms spread long continental shelf of the Atlantic Ocean. QIT and each of the production platforms have flare stacks where the associated gas is continuously flared. This gas flaring is known to release gaseous emissions to the atmosphere. On the average only a small fraction (1%-10%) of associated gas is utilized for power generation and re-injection to maintain well pressure while the rest is flared. Gas flaring is a common observation in host communities in the Niger Delta area where a lot of oil activities are carried out in the various oil fields.

Escravos Gas Project (1993) report showed that Nigeria flared more gas than any other country in the world (Grevy, 1995; World Bank, 1995). In 1989, Nigeria flared 617 billion standard cubit feet (SCF) of associated gas (World Bank, 1995). Environmental impacts of gas flaring have been reported to include amongst other impacts, acidic precipitation and subsequent corrosion of zinc roofing sheets and health impacts. These and other impacts are experience in Mbo. Arising from the fears of the impact of continued gas flaring by MPNU it became necessary to carryout the air quality and precipitation studies of Mbo Local Government Area and make recommendations to ameliorate the impacts.

The objectives of air quality, precipitation and corrosion studies in Mbo were to: (i) identify possible air contaminants that may be generated/emitted into the atmosphere through gas flaring at QIT or other MPNU locations, (ii) Outline the regularity and/or other acceptance limit/standards against which the ambient concentrations of these contaminants may be compared, (iii) determine the ambient concentrations of these contaminants in Mbo Local Government Area and compare these with regulatory limit/ standards and (iv) make recommendations.

MATERIALS AND METHODS

The baseline data were collected from literature sources and during a field survey carried out in November 2003. The sampling stations within the study area are shown in Figure 1. Since the predominant wind direction in the area is from the Southwest, air quality monitoring stations were established along this direction. Air quality measurements were carried out in three communities in Mbo (Fig. 1); namely Enwang, Etisong Ebughu and Ibaka.

Sampling and data collection at each location were in-line with recommended procedures and practices for environmental data collection in Nigeria (DPR, 1991). The limits/standards applicable to the possible air contaminants were determined from review of existing regulations, standards and codes, especially the Nigeria Ambient Air

Quality Standards (Appendix 1). Information on the health and other effects of the contaminants were obtained from various literature sources while the baseline concentrations were determined through field-testing and measurement.

AIR QUALITY MONITORING METHODOLOGY

Sampling and measurement of the chemical constituents of atmospheric pollutants (SPM, SO_x, NO_x, CO_x, H_2S and hydrocarbons) at each air quality sample location were measured in-situ using GC Gas monitors (sensitive digital gas monitors). The following hand held air quality monitoring equipment were used for measuring air quality. Sampling in each case was for a period of eight hours per day with reading of all the parameters determined every two hours. The eight-hour monitoring period was varied from day to day so that reading could be taken from early morning to late at night over the one-week monitoring period.

Carbon Monoxide (CO): An ELE carbon monoxide gas monitor model 463-022 was used for the detection of CO. The range of detection is between 0-100ppm with alarm set at 50 and 150ppm. Measurements were done by holding the sensor to a height of about two meters in the direction of the prevailing wind and readings recorded at stability.

Oxide of Sulphur (SO_x): An ELE sulphur dioxide gas monitor model 463-036 was used for the detection of SO_x. The range of detection is between 0-100ppm with alarm set at 2 and 6 ppm. Measurements were done by holding the sensor to a height of about two metres in the direction of the prevailing wind and reading recorded at stability.

Oxides of Nitrogen (NO_x): An ELE Nitrogen Oxide and Nitrogen Dioxide Gas Monitor Models 463-024 and 463-026 respectively were used for the detection of NO_x. The range of detection is between 0-100 ppm with alarm set at 2 and 6 ppm. Measurements were done by holding the sensor to a height of about two metres in the direction of the prevailing wind and readings recorded at stability.

Methane (CH_4): A Defender Multi Gas Detector, Model D2-2000, manufactured by DW Technologies was used for the determination of methane gas. The equipment detects the gas via a plug-in catalytic bead and has a detection range of 0-100% with alarm set at 5%. Measurements were done by holding the sensor to a height of about two metres in the direction of the prevailing wind and readings recorded at stability. The limit of detection is 0.01 percent.

Volatile Organic Carbons (VOC): A Multi RAE PLUS (PGM-50), a programmable Gas Monitor was used to monitor organic vapours. It has a Photo-Ionization Detector (PID) using 10.6-11.7 eV gas discharge lamp. It includes an integrated sampling pump - a diaphragm 0 and pump providing about 250 cc per minute flow rate at high 5% setting. It measures VOC over two ranges 0-200 ppm with a resolution of 0.1 ppm and 200-2000 mm with a resolution of 1 ppm.

Suspended Particulate Matter: A Cole-Parmer APC Plus Airborne Counter was use. The counter precisely measures the quantity of airborne particles with sizes above a set of fixed particle size (0.3μm , 0.5μm, and 5.0μm). It also simultaneously provides temperature, relative humidity, sample time and date of data. The instrument is composed of four modules: the sensor, pump, battery, and electronics.

The sensor module contains the optical components and temperature and relative humidity sensor. Within the particle sensor, light emitted from a laser diode is then absorbed in a light trap. When a particle enters the sensing zone, it scatters light from the beam. The light that is scattered is then collected by a second set of lenses and focused onto a solid-state photo detector. The amplitude of the electrical signal produced by the photo detector is dependent on the size of the particle in the sensing zone. The pump module draws air through the isokinetic probe past the temperature and humidity sensor and into the particle-sensing zone. The pump pulls in 0.1 cubic feet per minute of air.

Wind Speed and Direction: Digital hand held ELE Model 460-050 wind speed indicator was used to ascertain the wind speed of the various locations. The equipment determines the wind via wind cups that generate on revolution, signal that is directly proportional to the wind force. Holding the meter to a height of two metres in the prevailing wind direction did this. And compass Model M-73 was used to determine the direction of wind.

Noise and Vibration Level: A Cole-Parmer Extec Model 407736 Sound Level Metre was used to measure the noise level of the locations. Measurements were done by directing the probe towards the direction of the prevailing wind and reading recorded at stability.

Precipitation Studies: At each of the sampling stations, rainwater samples from roof and open space were collected during rains in plastic containers placed on elevated wooden stands. The samples were transported to the laboratory in clean bottles stored in coolers maintained at 4^0C with ice blocks for analysis. Water samples from streams in the communities were also collected in clean plastic bottles and transported in coolers to the laboratory for analysis. The parameters determined in the laboratory include pH, conductivity and chloride sulphate, nitrate and ammonium ions using standard methods.

Quality Assurance/Control Procedure: Strict Quality/Assurance procedures were adopted to cover all aspects of the study, including sampling, laboratory analyses and results documentation as recommended in DPR Guidelines and Standards (Part VIIID) Section 2.0 (1991).

RESULTS AND DISCUSSION

Gaseous Air Pollutants: The results of some gaseous air pollutants in the study area are presented in Table 1. While the oxides of sulphur, nitrogen and hydrogen sulphide were below the detection limits of the gas monitors used, carbon monoxide and methane were detected in air of the study area.

Table 1: Some Gaseous Pollutants in Mbo Local Government Area.

Sampling	Station	Parameters		
	SO_2 ($\mu g/m^3$)	$N0_2$ (ppm)	CD mg/m^3	H_2S (ppm)
Enwang	<1.43	<1	2.10	00
Ibaka	<1.43	<1	2.80	00
Etisong Ebughu	<1.43	<1	2.20	00

Source: Field Survey (2003)

Hydrocarbon Content of the Air in the Study Area

Volatile Organic Compound (VOC) and methane were used to determine the hydrocarbon present in the atmosphere of the study area. The results are as shown in Table 2: Natural background levels of methane (CH_4) in the atmosphere range from 784-980$\mu g/m^3$ (1.2-1.5ppm) on a worldwide basis (Peavey *et al,* 1985)

According to the Continuous Air Monitoring Project (CAMP) annual average of monthly maximum 1 hour average hydrocarbons (as carbon) range from 3.918-8.326$\mu g/m^3$ (8-17ppm) in major cities all over the world. Natural sources of VOC include anaerobic decomposition of plants in the swamp and marshes, seepage from natural gas oils field, and emission from trees while anthropogenic sources include emission from sources such as gas flares, motor vehicles, gasoline, petroleum refineries and petroleum chemical plants. Apart from gas flares from MPNU operations, other causes of VOC are almost non-existent in Mbo LGA. VOCs can react in the atmosphere to form NO_2 and CH_4. Measurements taken within the study area showed that ambient concentrations of methane and volatile organic carbons were above 0.01% and <0.01ppm, respectively. These values are above the regulatory limits/standards.

Table 2: Volatile Organic Compounds (VOCs) And CH_4

Sampling Station	Parameters	
	VOC	CH_4 (%)
Enwang	0.7	0.2
Ibaka	0.8	0.25
Etisong Ebughu	0.5	0.25

Source: Field Survey (2003)

Relative Humidity, Temperature, Wind Speed And Direction: Table 3 presents the temperature and relative humidity of Mbo LGA. The temperatures were generally high (36-37°C) while the relative humidity ranged from 53% to 54%.

Table 3: Wind Speed/Direction, Temperature and Relative Humidity of Mbo LGA.

Sampling Station	Parameters			
	Temp. (°C)	R.H (%)	Wind Speed (m/s)	Wind Direction
Enwang	37	53	<1	SW
Ibaka	36	54	<1	SW
Etisong Ebughu	36	53	<1	SW

Source: *Field Survey (2003)*

Table 4: Noise/Vibration Levels In Mbo LGA

Sampling Station	Noise (dB)	
	S.R	MAX
Enwang	39.2	44.0
Ibaka	45.3	49.3
Etisong Ebughu	38.5	46.6

Source: *Field Survey (2003)*

Noise and Vibration: Noise level at different sampling stations ranged between 38.5-49.3 dB (A) as shown in table 4. The noise level measured within the study area were within the FMENV 8-hour permissible exposure limit per day and the American Conference of Governmental Industrial Hygienist (ACGIH) threshold limit of 80 dB (A) per day (Appendix 2). All the recorded noise levels are above auditory threshold field (the dB level at which a pure tone is just audible), however all the measurements are below the threshold of discomfort (120 dB) and threshold of pain (140 dB).

The potential air pollutants addressed in this study are particulate matter, nitrogen oxides, sulphur oxides, methane, carbon monoxide and volatile organic carbons. All these are recognised in the Nigerian Ambient Air Quality Standards (FEPA, 1991) and are generated/emitted during gas flaring and other various operations and by some equipment during oil and gas production activities. The concentrations of atmospheric gases in what is considered to be clean dry air at ground level (in the troposphere that is, the layer of the atmosphere that contains the air that sustains life on earth) are presented in Table 5.

Sulphur Oxides: Sulphur dioxide (SO_2) is the oxide of sulphur that is of particular interest in air pollution studies. The gas is colourless, non-flammable and non-explosive and has a suffocating odour. It has a taste threshold of 784μg/m³ (0.3ppm) and an odour threshold of 1306μg/m³ (0.5ppm). Sulphur dioxide is soluble in water and can

form sulphuric acid droplets when it dissolves. Sulphuric acid and sulphur dioxide tend to irritate the mucous membranes of the respiratory tract, and foster the development of chronic respiratory disease, particularly bronchitis and pulmonary emphysema. The possible effects of the sulphur dioxide on human health are described in table 6.

Carbon Monoxide: Carbon monoxide is chemically inert under normal conditions, colourless, tasteless, and odourless. The estimated atmospheric mean life of the gas is about two and half months. Carbon monoxide has little (if any) effect on property, vegetation and materials. However, carbon monoxide at high concentrations can seriously affect human aerobic metabolism, owing to its high affinity for haemoglobin, the component of the blood responsible for the transport of oxygen. The gas reduces the capability of haemoglobin to carry oxygen even at low concentrations. The health effects observed in persons exposed to CO are described in table 7. Carbon monoxide and methane were detectable in the air of the study area while oxides of Nitrogen and Sulphur and hydrogen sulphate were below detectable limits of the hand held digital gas monitors more sensitive gas monitors with precision limits of below 1.00ppm or 1.00μ/m^3.

Table 5: Composition of Clean, Dry Air at Ground Level

Gas	Concentration by Volume (ppm)	Concentration by Volume (%)
Nitrogen	280, 000	78.06
Oxygen	209,500	20.95
Argon	9,300	0.93
Carbon Dioxide	320	0.032
Neon	18	0.0018
Helium	5.2	0.00052
Methane	1.5	0.00015
Krypton	1.0	0.0001
Hydrogen	0.5	0.00005
Dinitrogen Oxide	0.2	0.00002
Carbon Monoxide	0.1	0.00001
Zenon	0.08	0.000008
Ozone	0.02	0.000002
Ammonia	0.006	0.0000006
Nitrogen Dioxide	0.001	0.0000001
Sulphur Dioxide	0.0002	0.00000002
Hydrogen Sulphide	0.0002	0.00000002

Source: *Giddings (1973).*

Table 6: Possible Effect of Sulphur Dioxide on Humans

Concentration (ppm)	Exposure time	Effects
0 - 0.6	-	No detectable response
0.15 - 0.25	1.4 days	Cardio-respiratory response
1.0 - 2.0	3-10 mins	Cardio-respiratory response in health subject
1.0 - 5.0	-	Detectable responses, tightness in chest
5.0	1hour	Choking and increased lung resistance to air flow.
10.0	1hour	Severe distress, some nose-bleeding
< 20.0	-	Digestive tract affected, also eye irritation
100-500	-	Dangerous for short period of time

Source: *US Government (1970,1971)*

Table 7: Health Effects of Carboxyhaemoglobin (COHb)

COHb level	Demonstrated Effects
Less than 1.0	No apparent Effects
1.0-2.0	Some evidence of effect on behavioral performance
2.0-5.0	Central nervous system effects; impairment of time interval discrimination, visual acuity, brightness discrimination, and certain other psychomotor functions.
<5.0	Cardiac and pulmonary functional changes
10.0-80.0	Headaches, fatigue, drowsiness, coma, respiratory failure, death.

Source: *Wolf, (1971).*

Table 8: Health Effects of SPM

Cone (ig/m³	Accompanied by	Time	Effect
750	715μg/m³ SO_2	24-h average	Considerable increase in illness
300	630μg/m³ SO_2	24-h average	Acute worsening of chronic bronchitis patients.
250	250μg/m³SO_2	24-h average	Increased absence of industrial workers.
100-130	120μg/m³ SO_2	Annual mean	Children likely to experience increase incidence of respiratory disease.
100	Sulphation rate above 30mg/cm³	Annual geometric mean	Increased death rate for those over 50 likely
1-100	Sulphation rate above 30mg/cm³	2-year geometric mean	Increased death rate for those over 50 to 69 years.

Source: *US Government (1970;1971).*

Table 9: SPM Size and Respiratory Defense Mechanism

SPM Size	Description	Mechanism
> 10 μm	Coarse dust, fly ash (visible to the naked eye)	Filtered out by hair at the front of the nose
2-10 μm	Fumes dust, smoke particle	Movement of cilia sweeps mucus upwards, carrying particles from windpipe to mouth, where they can be swallowed.
>2 μm	Aerosols, fumes	Lymphocytes and phagocytes in the lung attack some sub-micron particles

Source: *US Government (1970; 1971)*

Nitrogen Oxides: The two oxides of nitrogen that are of primary concern in air pollution are nitric oxide (NO) and nitrogen dioxide (NO_2). Nitrogen dioxide is heavier than air and dissolves readily in water to form mainly nitric acid (HNO_3). This acid can fall out in the rain or combine with ammonia in the atmosphere to form a plant nutrient (ammonium nitrate). NO is not considered a health hazard because its concentration in ambient air is usually less than 1ppm. However, the gas can combine with haemoglobin to reduce the oxygen carrying capacity of blood. NO_2 irritates the alveoli of the lungs (PREDEC-FUGRO, 2001).

Hydrocarbons: According to Rabbel et *al* (1996) and Synder and Hedli (1996), the toxicity of some of hydrocarbon constituents like benzene involves both bone marrow depression and leukaemogenesis caused by damage to multiple classes of haematopoietic cell and a variety of haemotopoietic cell functions. Moreover, through the mylotoxic actions of some hydrocarbon constituents, some haematological changes ranging from pancytopaenia to total bone marrow aplasia, leukocytosis and leukocytopaenia have been reported (d' Azevedo *et al.*, 1996)

Suspended Particulate Matter (SPM): SPM is identified as any dispersed matter, solid or liquid, in which the individual aggregate is larger than a single small molecule (about 0.002mm in diameter) but smaller than about 5000μm (US Government, 1970; 1971). At high concentrations, SPM poses health hazards to humans, particularly those susceptible to respiratory illness. As indicated in Table 8 the nature and extent of the ill effects that may be linked to SPM depends on the concentration and the presence of other atmospheric contaminants and the duration of exposure.

The ways in which the human respiratory system defends itself against the invasion of foreign substances, including SPM, is presented in Table 9. The success or failure of the respiratory defense system depends in part on the size of the SPM inhaled and the depth of their penetration into the respiratory tract (US Government, 1970; 1971)

Generally, levels at which a pollutant will damage health depends on a variety of factors: nature of the pollutant, concentration of the pollutant, length of time the receptor is exposed to the pollutant, and general health of the receptor. The major effect of air pollutant on man's health and welfare are summarized in Table 10.

Table 10: Effects of Selected Air Pollutants on Man's Health and Welfare.

Agents/Pollutants	**Effects**
Sulphur dioxide (So_x etc)	Aggravation of respiratory disease; impairment of pulmonary function; irritation of eyes and pulmonary tract; leaf injury and reduced growth in plants; corrosion of metals.
Sulphur oxides and particulate matter from combustion sources.	Short-term increase in mortality and morbidity; contributory role in etiology of lung cancer (?)
Particulate matter otherwise specified.	Increase in chronic respiratory disease; impairment of visibility.
Hydrocarbons	Contribution of cancer (?); Sensory irritation
Carbon monoxide	Reduced tolerance for exercise; impairment of mental function.
Nitrogen dioxide	Aggravation of cardiovascular and respiratory illnesses.
Lead.	Increased storage in body; impairment of learning and intelligence in children.
Hydrogen Sulphide	Increase mortality from acute exposures; impairment of sensory detection/reflexes.

Sources: *Atkins Research and Development (1979).*

CONCLUSION AND RECOMMENDATIONS

The light methane and volatile organic carbon content of the air of the study area and the acidic pH of rain water from the area indicate that the acid rain is contributed by oil and gas activities in general and gas flaring in particular. Mobile Producing Nigeria Unlimited is the major oil and gas exploration and production company in the study area with general gas flare stacks in MPNU's near-shore oil fields (production platforms). The study area is a rural setting with very low traffic and no chemical industries. Also, other sources of atmospheric gaseous pollutants are almost non-existent. The likely source of acid precipitation in the study area therefore is the continuous gas flaring by MPNU, the second largest oil producer in Nigeria and the largest condensate producer in Africa.

From the above, the following recommendations are made to ameliorate the impact of gas flaring on the residents of Mbo LGA.

(1) In accordance with the FEPA (now Federal Ministry of Environment, FMENV) Law on Response, Compensation and Liability for Environmental Damage in

Nigeria (RECLED), the polluter (MPNU) should initiate moves to compensate the victims of air pollution in Mbo LGA in the spirit of good neighbourliness.

(2) A comprehensive regional air quality study should be carried out in the State to include (a) Measurement of ambient air quality; and (b) Measurements of Emission sources. This study will involve the use of standard air quality monitoring stations, measuring input data hourly for a minimum of three (3) years and a maximum of five (5) years.

(3) The Akwa Ibom State Ministry of Environment in collaboration with oil companies operating in the State should establish an Ecological Databank where baseline data could be retrieved for impact prediction. A project similar to the Niger Delta Environmental Survey (NDES) should be initiated for Akwa Ibom State since the State was not included in the NDES project.

(4) A comprehensive gas utilization master plan should be developed by MPNU and other companies to guarantee flares-out as soon as possible. This will not only eliminate the negative impact of gas flaring but will also increase the Nigerian gas reserves and therefore boost the Nigerian economy.

(5) The best way to prevent the effects of gas flaring is to stop gas flaring totally. It is recommended that gas flaring be stopped henceforth, throughout the country.

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APPENDIX 1: AIR QUALITY STANDARDS AND REGULATORY LIMITS

Nigerian Ambient Air Quality Standard (FEPA Guidelines and Standards for Environmental Pollution Control in Nigeria)

POLLUTANT	TIME OF AVERAGE	LIMITS
Particulates	Daily average of daily values 1 hour	250μg/m³ 600 μg/m³
Sulphur Oxides	Daily average of hourly values 1 hour	0.01ppm (26 μg/m³) 0.1ppm (260 μg/m³)
Non-methane Hydrocarbon	Daily average of 3 hourly values	(160 μg/m³)
Carbon monoxide	Daily average of hourly values 8-hourly average	10ppm (11.4 μg/m³) 20ppm (22.8 μg/m³)
Nitrogen Oxides	Daily average of hourly values (range)	0.04ppm-0.06ppm 75.0 μg/m³- 113 μg/m³
Photochemical Oxidant	Hourly values	0.06ppm

World Bank Environmental Guidelines on Ambient Air Pollutants

Pollutants	Limit
Particulates Matter Annual Arithmetic Mean Maximum 24 hour Peak.	80 μg/m³
Oxides of Nitrogen Annual Arithmetic Mean	500 μg/m³
Sulphur Dioxide Annual Arithmetic Mean Maximum 24-hour Peak	100 μg/m³ 500 μg/m³

WHO Guidelines and Standards for Ambient Air Quality

Pollutants	Limit
Particulates Matter	150-230μg/m³ 24 hours 60-90 μg/m³ 1 year
Carbon Oxides	30μg/m³ 1 hour 10 μg/m³ 8 hour
Nitrogen Oxides	400 μg/m³ 1 hour 150 μg/m³ 8 hour
Sulphur Oxides	350 μg/m³ 1 hour 100μg/m³ 24 hour 40-60 μg/m³ 1 hour

APPENDIX 2: Permissible Noise Exposure Level – FEPA and OSHA Standards

Duration/Day – Hours	Sound Level (Dba) Slow Response
8	90
6	92
4	95
3	97
2	100
$1^{1}/_{2}$	102
1	105
½	110
$^{1}/_{4}$	115
Impulsive or impact Noise	<140dB, Peak

Permissible Noise Exposure – ACGIH Standards

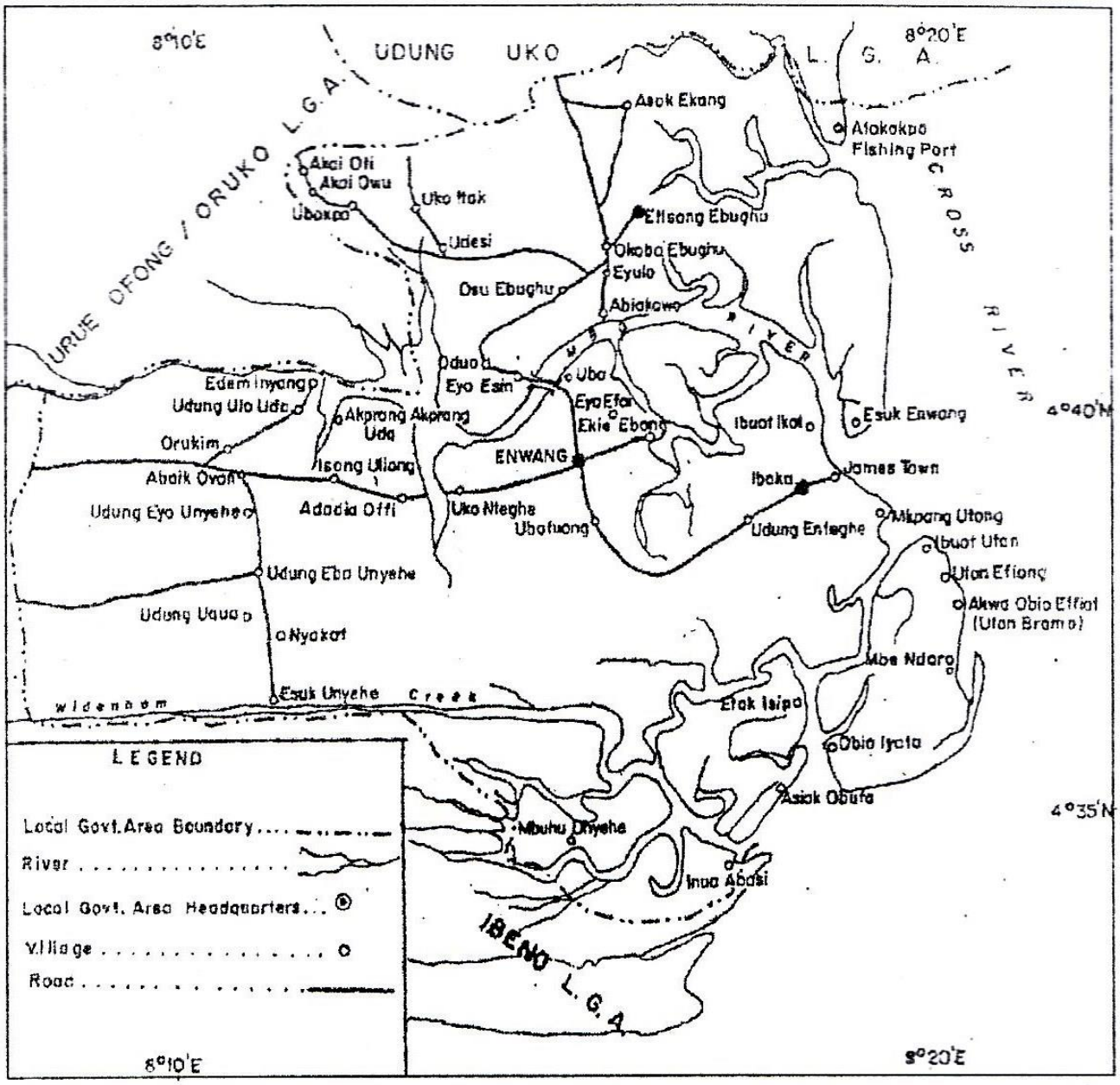
Duration/Day – Hour	Sound Level (Dba)
8	90
6	92
4	95
3	97
2	100
1	102
1½	105
½	110
1/4	115

Permissible Noise Exposure (impulsive/Impact) Thresholds – ACGIH Standards

dB, Peak	Permitted Impacts/Day
140	100
130	1,000
120	10,000

Acceptable Exposure to Noise (dBA) as a Function of Number of Occurrences Per Day

24-Hour Duration		Number of Times the Noise Occurs per Day						
Hrs	Min	1	3	7	15	35	75	160up
8		90	90	90	90	90	90	90
6		91	93	96	98	97	95	94
4		92	95	99	102	104	102	100
2		95	99	102	106	109	114	
1		98	103	107	110	115		
	30	101	106	110	115			
	15	105	110	115				
	8	109	115					
	4	113						



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Key: ●= Sampling Stations

Fig 1: Map Of Mbo Lga Showing Sampling Stations.